ELECTRO DIAGNOSIS

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ELECTRO-DIAGNOSIS

SCHEME

FOR THE

DIFFERENTIAL TESTING

OF

NERVES AND MUSCLES

FOR USE IN DIAGNOSIS

BY

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To

Dr. Henry Hun

Professor of Diseases of the Nervous System in the

Albany Medical College

as a token of affectionate regard

PREFACE

These tables have been prepared for the purpose of facilitating electro-diagnosis. They are the result of repeated examinations made at the Albany Hospital, which have shown the great advantages of precise anatomical localization over the time-honored charts of von Ziemssen. No other publication exists, so far as I know, in which the nerve and muscle groups have been classified for this purpose, nor has there been any attempt at such descriptions in English.

The use of this method in teaching the action of nerves and muscles is far less common than its advantages deserve. It may be also worthy of note that the demand for electrical testing has come from the surgical division of the Hospital, particularly since the introduction of the operation for tendon transplantation in the correction of paralytic deformities.

The comparative infrequency of departures from the established points has given encouragement to the completion of the scheme, and an exact localization is attainable in the great majority of cases. The exceptions to this rule have been observed principally in children, probably from the disproportionate size of the limbs.

I am indebted to Dr. Charles M. Culver for assistance in the adaptation of Bourgery's classical plates to the purpose of the book.

ALBANY, N. Y., *December, 1902*

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The Technique of Electro-Diagnosis

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Electro-diagnosis is the art of determining the normal or abnormal condition of the susceptibility of the motor and sensory organs to electric currents.

Electro-diagnosis is conducted by the sudden application of accurately measured and graduated currents to circumscribed parts of the surface, so as to excite (1) individual nerve trunks or branches, and (2) individual muscles or segments. Skill is required in making the tests, in order that the necessary intensity and density of the current may be applied so that this shall be limited to the parts under examination, and shall not affect neighboring tissues. The so-called "motor points" are the areas upon the surface at which the individual nerves supplied to the individual muscles are most easily reached. For the nerves these points overlie their approach to the surface; for the muscles, the entrance of the nerve into the muscle. When a healthy nerve is sufficiently stimulated a contraction of all the muscles supplied by this nerve below the point of stimulation results; this is known as "indirect" excitation. When a muscle or muscle segment is stimulated the muscle or segment only responds; this is known as "direct" excitation.

The apparatus required for electro-diagnosis consists of:

(1) A galvanic battery of from thirty to fifty cells, provided with a current collector arranged to throw in circuit individual groups of cells, a current controller or rheostat, a milliampèremeter with shunt or scales of different capacity, and a pole changer;

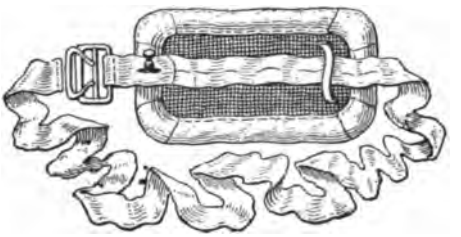
(2) A standard induction coil, supplied by from one to four cells, with an arbitrary scale showing the degree of approximation of the secondary to the primary coil (for which

may be substituted the readings of the rheostat or current controller already provided);

(3) A switch for changing the currents;

(4) Two well insulated conducting wires about four feet in length;

(5) An "indifferent" electrode, preferably a covered wire



gauze pad giving a surface of about twelve square inches, and provided with a strap or belt to hold it in place; and a "differential" button-shaped or spherical electrode of surface of half a square inch, with an interrupting handle.

The patient should be placed in a good light so that the slightest visible contraction may be seen, and the position of the part under examination should be established with as nearly complete relaxation of the muscles as possible. A sitting posture is best for the examination of the head, neck and upper extremities. The upper extremities should rest upon a table or upon the knee of the operator, who may find it convenient to place one foot upon the edge of the patient's chair for this purpose. Trunk muscles may be examined when the patient is either sitting or lying. For the lower extremities a suitable rest may be found with the patient sitting, but the most satisfactory results will be obtained with the patient reclining. The group of muscles about the but-

tock and hip may be advantageously tested while the patient is standing in the manner described in the text.

The operator may stand or sit as occasion requires, and should have an assistant for manipulation of the battery, and another, when possible, to record the results of the examination.

In the examination of a child the patient should be familiarized with the electrodes by handling them, and one or two applications may be made before the current is transmitted.

Examination of Muscles. Muscles should be tested first. Any apparently affected muscle may be selected, and in the event of an abnormal electrical response, the remaining muscles of the same group, and finally the nerve by which they are supplied.

The battery being in readiness, the electrodes are moistened in warm water (a salt solution is rarely necessary and is not advised), and the large "indifferent" electrode is fastened in place at the nuchal region, over the sternum or upon the epigastrium. The electrodes should never be pressed together, as is often carelessly done, to remove the superfluous water, nor should they be placed simultaneously in the water used for moistening them, as both of these procedures cause a short circuit, which is very detrimental to the battery.

The steps of the test are as follows:

Find the motor point required by its anatomical localization.

Place the testing electrode, well moistened, upon this point, grasping the handle with the thumb on the interrupter, and apply steady, firm pressure, with the current open. Do not remove the electrodes or alter the pressure until the test is completed. In some localities care must be taken that the contraction of a neighboring muscle does not dislodge the electrode, as, for instance, in the examination of the musculospiral nerve, where a slight deviation to one side or the other brings into action the biceps or triceps.

The test begins with the negative pole of the faradic cur-

rent. Increase gradually the strength of the current, by approximation of the coils or by means of the rheostat or current controller, during successive makes and breaks with the key of the interrupting handle, until the minimal visible contraction of the muscle is seen. The operator should not allow himself to be deceived by a voluntary contraction.

Record the amount of current used and the character of the contraction.

Break the current.

Exchange the faradic for the galvanic current by the switch, and place in circuit one or more groups of galvanic cells, the milliampèremeter and the rheostat.

Increase the current gradually by means of the current controller or rheostat, during successive interruptions, as before, until the minimal muscular contraction is seen, when the current is to be kept closed.

Record the number of milliampères required for the contraction by the reading of the milliampèremeter. If the application is difficult and the needle oscillates, take quickly the mean reading between the extremes of the oscillations.

Note the character of the contraction, whether it is quick and "lightning-like," sluggish, or vermicular and wavy. If this cannot be determined a stronger contraction must be obtained by increasing the current.

This is the Cathodal Closure Contraction—CCc.

Break the current.

Reverse the poles.

Close the current, after an interval of at least five seconds.

Increase or decrease the current strength with successive closures until a contraction of identical character with the cathodal closure contraction occurs.

Record the reading of the milliampèremeter, and the character of the contraction, as before.

This is the Anodal Closure Contraction—AnCc or ACc.

Break the current, after at least five seconds, watching carefully whether or not a contraction occurs at the breaking. If not, increase the current until it is seen.

This is the Anodal Opening Contraction— AnOc or AOc.

The test will have shown whether the response to the faradic or galvanic current is wanting, the character of the contraction, the predominance of one or the other pole, and the relation of the anodal opening to the anodal closing contraction.

If advisable, compare the results with those of similar tests upon the opposite side of the body.

Examination of Nerves. This is to be conducted in the same way as the examination of muscles. It is to be noted whether all muscles supplied by the nerve contract promptly, or whether some do and others do not.

Synopsis

If the muscle responds to the faradic current in moderate strength, and the contraction occurs suddenly on closing the current, continues during the flow and disappears abruptly on the opening, and the minimal cathodal closure in response to the galvanic current is greater than the minimal anodal closure, and the contraction is prompt, the electrical conditions are normal, and the test may be transferred to another muscle. If the contraction elicited by the galvanic current is exaggerated or sluggish, or the anodal closure contraction is equal to or greater than the cathodal, some pathologic condition is present, and a complete examination of nerves and muscles should be made and recorded.

Variations in Electric Excitability

Variations in Electric Excitability

Different nerves and muscles, and the same nerves and muscles at different times, vary in excitability in the same individual and in different individuals. These differences exist in health and are normal. Quantitative morbid changes in excitability, consisting merely of simple diminution or simple excess, may be determined by comparison of the reaction in homologous structures of both sides when one side only is affected, or by comparison of the reactions with those of healthy persons when bilateral disease exists. For this purpose tables have been arranged by Stintzing, showing the upper and lower limits of the electrical excitability in health, with the averages, of certain nerves and muscles, and these tables may be used in certain cases. The extremes in other cases are so great that abnormal electrical responses due to disease may be still within the normal limits. Qualitative changes in electrical excitability are always abnormal. The tables prepared by Stintzing are based upon a great number of examinations with a testing electrode having a diameter of two centimetres, and giving an active surface of about three square centimetres. For comparison of the faradic measurements a standard coil as used by Stintzing is required. Ordinarily this is not available, and faradic variations are determined empirically by practice with the apparatus used by the examiner.

Table of Galvanic Excitability of Nerves

(After Stintzing)

I.—THE MOST EXCITABLE GROUP

Excitable from 0.5 to 1.0 milliampère

	BOUNDARIES.		AVERAGE.
	LOWER.	UPPER.	
	ma.	ma.	ma.
N. Musculo-cutaneous	0.05	0.28	0.17
Eleventh	0.10	0.44	0.27
Ulnar (above olecranon).	0.2	0.9	0.55

II.—THE MIDDLE GROUP

Excitable from 1. milliampère to 2. milliampères

N. External popliteal	0.2	2.0	1.1
Median	0.3	1.5	0.9
Crural.....	0.4	1.7	1.05

III.—THE LEAST EXCITABLE GROUP

Excitable from 2.0 to 2.5 milliampères

N. Internal popliteal	0.4	2.5	1.45
Ulnar (at wrist).....	0.6	2.6	1.6
Musculo-spiral	0.9	2.7	1.8
Facial	1.	2.5	1.75

Table of Faradic Excitability of Nerves

(After Stintzing)

(The figures refer to the degree of approximation in millimetres of the secondary to the primary coil.)

	BOUNDARIES.		AVERAGE.
	LOWER.	UPPER.	
N. Eleventh	145	130	137.5
Musculo-cutaneous	145	125	135
Ulnar (above olecranon)	140	120	130
Median	135	110	122.5
Facial	132	110	121
Ulnar (at wrist)	130	107	118.5
External popliteal	127	103	115
Crural	120	103	111.5
Internal popliteal	120	95	107.5
Musculo-spiral	120	90	105

Variations in electrical excitability may be (*a*) *quantitative*, in which the strength of the response through the nerve only is affected; (b) *qualitative*, in which the responses of the muscles to both currents differ from those of health in form and intensity; and (*c*) *quantitative-qualitative*, in which there are combined changes of response of both classes.

(*a*) Quantitative Variations in Electric Excitability

INCREASE OF ELECTRIC EXCITABILITY

Increase of faradic excitability consists of stronger contractions of the muscle to the ordinary strength of current, indicated by the current controller, rheostat, or by the degree of approximation of the secondary to the primary coil.

Increase of galvanic excitability is indicated by decrease in the strength of the current required to elicit a minimal contraction, measured by the milliampèremeter, or by increased vigor of the contraction with currents of ordinary strength; the cathodal closure contraction takes place with less current, and is very quick, passing rapidly, with slight increase in current, to tetanus; the anodal contractions appear early, and finally, the highest grade of contraction, anodal opening tetanus, appears.

Occurrence. Quantitative increase of excitability has been observed in moderate degree in fresh hemiplegias, occasionally in the initial stage of locomotor ataxia, and at the beginning of certain peripheral palsies, as rheumatic facial paralysis and pressure paralysis of the musculo-spiral nerve. In these cases the symptom is transient and unimportant.

Tetany. Increased excitability is pathognomonic of tetany (*Erb's Phenomenon*). Marked quantitative increase of excitability of the nerves, in which the muscles may or may not participate, is found in response to both galvanic and faradic currents, and the contraction may follow a galvanic current derived from one cell (one milliampère or two milliampères). The minimal contraction occurs with the closing or opening of the current at the anode, which predominates over the cathode, and this disease affords the only instance in man of anodal opening tetanus. The contraction may persist after the current is broken.

The diagnostic value of Erb's phenomenon lies in the differentiation of tetany from certain simulating conditions, especially spastic states of the extremities in hysteria.

DECREASE OF ELECTRIC EXCITABILITY

Diminished faradic excitability is shown by a response of ordinary strength only on closer approximation of the secondary to the primary coil; or, with currents of increasing strength, by diminution of the intensity of the contraction, which becomes weaker until, with the strongest currents, no contraction occurs and faradic excitability is entirely lost.

Diminished galvanic excitability is shown by weakened response to the ordinary strength of current; the minimal cathodal closure contraction requires a greater strength of current, and the induction of cathodal closure tetanus, anodal closure and cathodal opening contractions requires an excessively large amount of electricity. The reactions gradually diminish so that the cathodal opening contraction is not attainable, anodal responses grow weaker, and finally the cathodal closure contraction is the only response. When the cathodal closure contraction can no longer be obtained the galvanic excitability is entirely lost.

Occurrence. Decrease in electrical excitability may be quantitative or qualitative. Quantitative decrease occurs in conditions inhibiting the activity of muscles or nerves, without the presence of organic changes. Any form of paralysis or paresis due to lesions of the central neuron, or to lesions of the peripheral neuron without degeneration, may be followed by quantitative diminution of electrical excitability.

In cerebral palsies simple quantitative diminution of excitability may occur, but is not common and has no diagnostic significance. The same is true of diseases of the brain stem, the peduncles, pons and medulla, in which lie the nuclei of the motor cranial nerves; and in diffuse or system dis-

eases of the spinal cord not invading acutely the trophic cells of the anterior horns. When the lower trophic centres are involved in destructive lesions the quantitative changes are associated with qualitative changes, described below as the reaction of degeneration. The appearance of qualitative changes, in connection with quantitative, indicates degenerative atrophy, which makes the prognosis more unfavorable.

The peripheral nervous diseases accompanied by simple quantitative decrease in electrical excitability may be included under the general term "atrophies of disuse." The affections predisposing to these are joint lesions, "arthritic palsies," and traumatic conditions, as the temporary palsies following dislocations, and pressure from bandages and splints, as Volkmann's contracture.

Muscular diseases are occasionally accompanied by simple diminution of electrical excitability, as the muscular dystrophies, the juvenile and infantile forms of muscular atrophy, pseudohypertrophy and occupation atrophies. The negative value of the casual electrical changes in these conditions in differentiating peripheral diseases from spinal cord affections is discussed below under the reaction of degeneration. Simple diminution has also been observed in myositis, as in trichinosis.

(*b*) Qualitative Variations in Electric Excitability

Qualitative occur only in association with quantitative changes, giving

(*c*) Quantitative-Qualitative Variations in Electric Excitability

The quantitative-qualitative changes are (1) the reaction of degeneration; (2) the myotonic reaction; (3) the myasthenic

reaction; (4) the myoclonic contraction, and (5) the neurotonic reaction.

(1.) THE REACTION OF DEGENERATION

The reaction of degeneration is an abnormal response of the muscle to the galvanic current, characterized by a sluggish, wavy, or vermicular contraction, which shows a tendency to persist after the current is withdrawn, instead of by the lightning-like, sudden contraction which occurs in health immediately upon closing the circuit. This form of contraction is the "modal change," and is usually associated with other abnormalities of electrical reaction in the nerve and muscle, known respectively as the "quantitative change," the "qualitative change," and the "polar change."

The "quantitative change" consists of loss of response through the nerve to both the faradic and galvanic currents.

The "qualitative change" consists of loss of response by the muscle to the faradic current, and increased activity of response to the galvanic current, so that a very small current elicits a contraction.

The "polar change" consists of reversal of the normal formula of contraction, by which the response to the cathode becomes progressively less, and that to the anode, greater, until eventually the anodal contraction equals or exceeds the cathodal.

Instead of CCc > ACc or AOc, the formula becomes ACc or AOc = or > CCc.

All degrees of the reaction of degeneration may be seen, from the complete form to a partial form in which only the changed quality of the muscular response to the galvanic current exists. The degree of the reaction depends upon the activity or severity of the process of degenerative atrophy in the nerves and muscles. The complete form is seen only in

traumatic lesions of the peripheral nerves of sufficient extent to produce solution of continuity, as in division by laceration or incision.

The only essential and pathognomonic sign of the reaction of degeneration is the peculiar sluggish quality of the response of the muscle to the galvanic current.

The Mild Degree of the Reaction of Degeneration

When a paralyzing injury or disease of the peripheral motor neuron occurs, no electrical changes are at first seen. In a short time, from five to seven days, the responses of the nerve to the galvanic and faradic currents, and of the muscle to the faradic current, diminish, and by the end of the second or third week, are completely lost, so that the strongest currents excite no contraction. The galvanic excitability of the muscle also declines for a few days, but during or by the end of the second week, the response of the muscle to galvanic stimulation rapidly increases, and a very weak current induces a noticeable contraction, which is sluggish and wavy. At the same time the response to the cathode diminishes and that to the anode increases, until the anodal closure contraction equals or exceeds the cathodal closure, and the polar formula is reversed. These changes coincide with the process of degenerative atrophy in the nerve and muscle.

After a variable period, of from four to eight weeks, a few days later than vestiges of returning voluntary motion, faradic and galvanic excitability of the nerve and faradic excitability of the muscle gradually return, the increased galvanic excitability of the muscle diminishes, the wavy, sluggish response becomes quicker and more lightning-like, and the poles assume their normal relations. This corresponds with the process of regeneration of the nerve and muscle.

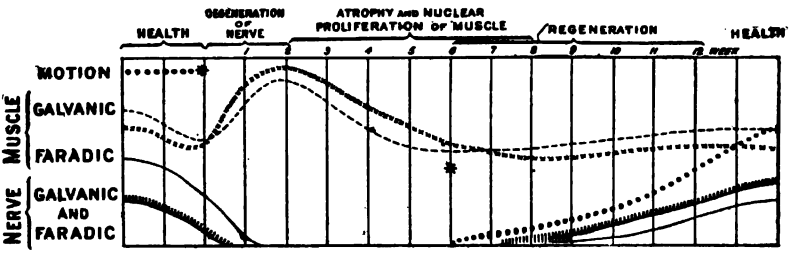


CHART 1. Graphic representation of the course of the mild degree of the reaction of degeneration. (Modified from Erb.)

The stars show, respectively, the sudden loss and beginning return of motion, which is shown by a line of circles. The galvanic excitability of the muscle is shown by lines of +, + and —, —, indicating the reversal of the poles; faradic excitability of the muscle, by a continuous line, and galvanic and faradic excitability of the nerve by a serrated line.

The Medium Degree of the Reaction of Degeneration

The medium degree of the reaction of degeneration is similar to the mild degree, except that the condition is more prolonged. Voluntary motion returns from the fourth to the eighth month, or even later, and regeneration begins, with restoration of the normal electrical conditions, in from six months to one year.

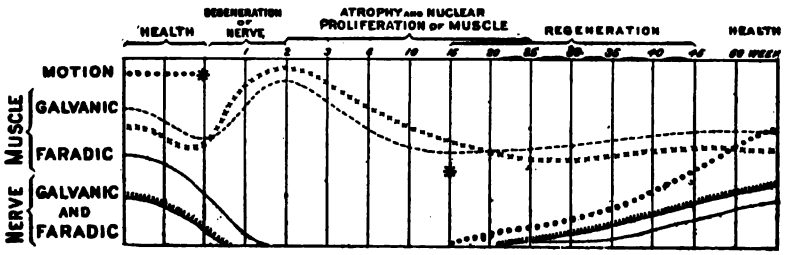


CHART 2. Graphic representation of the course of the medium degree of the reaction of degeneration. (Modified from Erb.)

The Severe Degree of the Reaction of Degeneration

In the severe form regeneration does not occur, and the structures pass on to irreparable atrophy and proliferation of connective tissue. The faradic and galvanic excitability of the nerve and the faradic excitability of the muscle disappear

and do not return. The galvanic excitability of the muscle, with the modal and polar changes, takes place as before, reaching its height in the course of the second or third month, when it begins to decrease, and greater strength of current is required to elicit the contraction. The response continues to diminish until the end of the second year, when the cathodal closure contraction disappears, then the anodal closure, until all electric excitability of nerve and muscle is permanently lost.

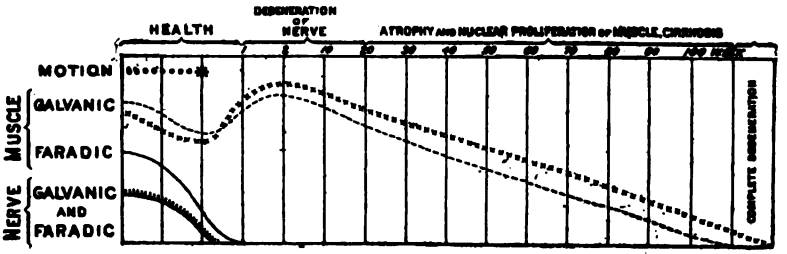


CHART 3. Graphic representation of the course of the severe degree of the reaction of degeneration. (Modified from Erb.)

Atypical Forms of the Reaction of Degeneration

1. The quantitative change may be wanting, and the nerves continue to respond either to the usual strength, or, more commonly, to increased strength, of the faradic and galvanic currents, while the modal, qualitative and polar changes in the muscles are present. This is known as the *Partial Reaction of Degeneration.*

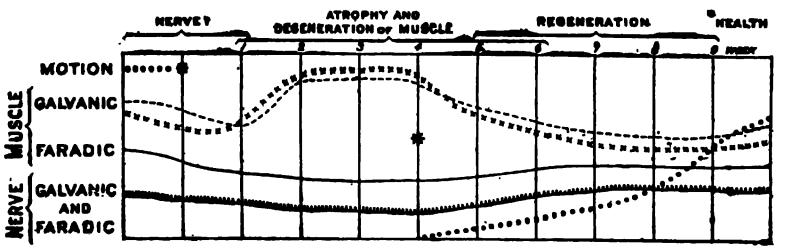


CHART 4. Graphic representation of the course of the partial reaction of degeneration. (Modified from Erb.)

2. The Partial Reaction of Degeneration may be further modified by persistence of the faradic excitability of the muscle, which responds to the ordinary strength of current, or may require an increased amount.

3. The polar change may be absent, and the cathodal closure contraction continue more pronounced than the anodal contractions.

4. Sahli notes another modification of the partial reaction of degeneration, in which all of the responses are slow, those which are elicited by faradic excitation of the muscle and faradic and galvanic stimulation of the nerve, as well as those resulting from galvanic stimulation of the muscle.

5. Occasionally the electrical responses are characterized by a mixture of normal contractions with those suggesting the reaction of degeneration, both forms being displayed in the same muscle. This may be a feature of certain cases of partial reaction of degeneration, and is due to the activity of healthy muscle fibres lying side by side with degenerated fibres in the same muscle. The term *Mixed Reaction of Degeneration* has been applied to this phenomenon.

OCCURRENCE OF THE REACTION OF DEGENERATION

The reaction of degeneration is a symptom of degenerative atrophy of nerves and muscles, and consequently appears in degenerative diseases or injuries of the peripheral motor neuron, of the nuclei of the cranial nerves, the multipolar cells of the anterior horns of the cord and the motor peripheral cranial and spinal nerves.

The Pons Varolii and Medulla Oblongata

The reaction of degeneration appears in any form of pontine or bulbar paralysis, acute or chronic, as hæmorrhage, degen-

eration, tumors, affecting the nuclei of the motor cranial nerves susceptible to electrical examination, as the motor branch of the fifth, the seventh, eleventh and twelfth. The value of its presence or absence lies in the differentiation from lesions of the cortex or motor tracts between the cortex and peripheral nerve nuclei, which produce no such symptoms of degeneration. While the absence of the reaction of degeneration in peripheral nerve disease is of distinctly favorable import, this is not true of central lesions. Its absence in central lesions may be of great assistance in the elaboration of the diagnosis, but is of no significance in relation to the prognosis.

Progressive chronic bulbar paralysis. (*Glosso-labio-laryngeal paralysis.*) The electrical excitability of the muscles shows diminution, and the reaction of degeneration is at times to be seen in advanced atrophy. The electrical reactions in this disease are similar to those of the spinal form of progressive muscular atrophy, with which it is in relation.

The Fifth Nerve

In addition to nuclear affections, the fifth nerve may be involved in diseases of the base of the brain giving rise to secondary neuritis, as meningitis, especially syphilitic, and bone caries. The motor branch passes through the spheno-maxillary fossa, where it is susceptible to the pressure of pituitary tumors, and to wounds through the nose and throat.

The motor branch is rarely diseased alone, and is not available for direct electrical stimulation, nor are the pterygoid muscles for indirect. The masseter and temporal muscles are easily reached upon the face. They require a current of greater than average strength, and care must be taken in the examination to prevent confusion with the distribution of the seventh nerve.

The Seventh Nerve

As an exclusively motor nerve of wide superficial distribution and important function, the seventh nerve is susceptible to many diseases in which abnormal electrical conditions are prominent. In addition to nuclear affections, the trunk and branches of the nerve are particularly liable to traumatism and inflammatory conditions, and the entire distribution is available for both direct and indirect electrical stimulation.

Injuries to the nerve arise from fracture of the base of the skull, through the Fallopian canal in the petrous bone, obstetrical accidents and blows or operations about the ramus of the jaw.

Inflammatory processes may be primary, as in syphilis or other forms of infectious neuritis. With them may be placed the common form of facial neuritis, known as "rheumatic," or "idiopathic," the most frequent manifestation, as well as the most important, of disease of this nerve. Facial paralysis is also secondary to otitis media, meningitis and caries of the temporal bone, its implication arising from contiguity. Wilks and Moxon and Gowers have reported cases of facial paralysis arising from hæmorrhage into the nerve sheath or the Fallopian canal. Locomotor ataxia is also a rare source of disease of this nerve.

The electrical reactions in nuclear or peripheral facial paralysis give valuable evidence of the locality and severity of the process, and are thus important both in diagnosis and prognosis. In the lighter forms, those without degenerative atrophy, there is no electrical change, or only a slight increase of excitability for one or two days, and recovery may be expected in two or three weeks. In attacks of moderate severity, slight diminution of faradic and galvanic excitability of the nerve, and of faradic excitability of the muscles, appears during the second week, while the galvanic excitability of the

muscles is increased and the contraction becomes sluggish, with or without reversal of the poles: the partial reaction of degeneration. In this form a moderate degree of degenerative atrophy is present, and recovery will require from six to eight or ten weeks. In the severe form, the complete reaction of degeneration is present in either medium or severe degree, and restoration will not ensue for from eight months to a year or more, and may always remain incomplete.

The Spinal Cord

The reaction of degeneration may appear in any disease of the spinal cord which affects the multipolar cells of the anterior horns, as (*a*) infantile paralysis, (*b*) amyotrophic lateral sclerosis, (*c*) progressive muscular atrophy, (*d*) locomotor ataxia invading the anterior horns; and diffuse lesions, as (*e*) transverse myelitis, (*f*) disseminated sclerosis, (*g*) hæmorrhage, (*h*) tumor, (*i*) gliomatosis and syringomyelia. Affections of the meninges or vertebræ involving the motor nerve roots may also be accompanied by the reaction of degeneration.

Infantile Paralysis. Infantile paralysis is the type of acute atrophic disease of the spinal cord. The lesion is diffuse and irregular and affects groups of cells in the anterior horns presiding over the nutrition of muscles functionally related. The distribution of the paralysis is thus different from that due to lesions of the peripheral nerves. In light forms affected segments or scattered fibres of individual muscles lie side by side with healthy tissue, and the electrical reactions are determined by the dominating influence. Different degrees of electrical activity are found in different muscles. In muscles which are weak and do not atrophy, simple quantitative diminution of electrical excitability may be the only change. Modified forms of the reaction of degeneration may be seen, but the common type of electrical response in this disease is the complete reaction of degeneration in its characteristic

form, progressing toward loss of electrical excitability. The use of the galvanic current in treatment prolongs the activity of the muscles and the final disappearance of electrical responses may be delayed for three or four years. The electrical examination is conducted with reference to the distribution of the paralysis and without regard for anatomical groups of muscles.

Amyotrophic Lateral Sclerosis and Progressive Muscular Atrophy. The importance of abnormal electrical reactions in muscular atrophies lies in the differentiation of the spinal from the myogenic forms, as pseudohypertrophy and the dystrophies. The presence of the reaction of degeneration in a doubtful case of this class is proof of spinal cord disease, as this symptom never occurs in the trophic disorders of muscular origin. The symptom is not always present, however, as healthy fibres are mingled with those degenerated, and may predominate. Different forms of reaction are found, as simple diminution of excitability in response to both currents, and complete, or, more usually, partial, reaction of degeneration with simultaneous diminution of excitability.

Gliomatosis and Syringomyelia. This condition closely resembles progressive spinal muscular atrophy in its motor and trophic symptoms, and the electrical reactions are subject to the same laws.

Diffuse Lesions of the Spinal Cord. Locomotor ataxia in advanced form, disseminated multiple sclerosis, transverse myelitis, hæmorrhage and tumor, produce changes in electrical excitability of varied character and degree when the anterior horns participate in the lesions.

Affections of the Meninges and Vertebrae may involve the motor nerve roots in traumatic or inflammatory disease with exudate, producing electrical changes in the distribution of the segments affected.

The Peripheral Nerves

Degenerative atrophy in the peripheral nerves is due to (1) injuries, (2) inflammation, and (3) new growths.

Injuries to the Peripheral Nerves. Injuries which cause the reaction of degeneration are stab and sabre wounds, and the punctured wounds of hypodermatic injections. The various forms of pressure paralysis constitute a special class. The brachial plexus may be injured at the supraclavicular point of Erb, by obstetric forceps, or by the anæsthetist during surgical operations, or from falls. The resulting paralysis affects the deltoid, biceps, brachialis anticus and supinator longus. Similar conditions in the distribution of the musculo-spiral nerve (occasionally associated with disorder of the median) have been recognized as "drunkard's," "sleep," "crutch" or "honeymoon" palsy. The electrical reactions depend upon the severity of the injury. Ordinarily in pressure paralysis simple diminution of electrical excitability is the only change, but the reaction of degeneration may occur.

Inflammation of the Peripheral Nerves. In multiple neuritis, either infectious or toxic, complete or partial reaction of degeneration may be present. The electrical changes may precede the subjective symptoms. Certain cases of polyneuritis have been found in which there is a high degree of diminution of all forms of electrical excitability. It has been assumed in these cases that the toxic excitant has invaded not only the nerves but the muscular parenchyma as well, thus interrupting the degenerative atrophy with its associated characteristic electrical reactions.

In lead palsy the reaction of degeneration is present. Cohn calls attention to the fact that this reaction may be found in muscles not obviously paralyzed, as the supinator longus. No explanation has been given for this phenomenon.

Tumors of the Peripheral Nerves. Tumors of the nerves

may so involve the fibres as to induce degenerative atrophy with the characteristic complete or partial reaction of degeneration.

Neuroses

The absence of altered electrical conditions in functional disease is an important resource in the differential diagnosis. This is a particularly valuable distinction in litigation cases in which monoplegias or other forms of psychic or hysterical paralysis incident to the "traumatic neuroses," closely simulate organic disease.

2. THE MYOTONIC REACTION

A peculiar quantitative-qualitative reaction has been described by Erb as characteristic of congenital myotonia (Thomsen's disease). The electrical conditions in the nerves are not affected. The muscle responds to a current of diminished strength, and the contractions are slow and persist for several seconds after the withdrawal of the electricity. They are frequently rhythmic and wavy during the stabile application of the galvanic current. The electrical excitability is thus analogous with the increased mechanical irritability in this disease.

3. THE MYASTHENIC REACTION

The myasthenic reaction consists of rapid exhaustion of the faradic excitability of muscles. The muscle responds promptly and normally to the faradic current, but the contraction grows weaker, either with continuous application, or with rapid consecutive applications, until the response ceases. After a brief period of rest excitability returns and the phenomenon is repeated. This reaction is probably pathognomonic of myasthenia gravis.

4. MYOCLONIC CONTRACTIONS

Myoclonic contractions are clonic movements of the fibres or bundles of muscles, in place of the normal tetanic response

to the faradic current, following one another during the transmission of the current. Such contractions indicate weakness, and are not of important diagnostic significance.

5. THE NEUROTONIC REACTION

In the so-called neurotonic reaction the contraction persists after withdrawal of both the galvanic and faradic currents when applied to the nerves alone. Responses to the positive pole predominate over those to the negative pole, and anodal tetanus may be produced. The direct muscular responses are normal. The reaction has been found in a case of hysteria by Marina, and in progressive muscular atrophy by Remak, but its significance is not understood, and it is at present to be regarded as a curiosity.

Electric Sensibility

ELECTRO-CUTANEOUS SENSIBILITY

For tests of the sensibility of the skin the faradic current is used. The patient should sit with his back toward the battery. A special testing electrode has been suggested by Erb, presenting a flat metal surface consisting of a great number of wires. The ordinary wire brush may be used. This electrode need not be moistened. The indifferent electrode is placed as in electro-muscular tests, and the differential electrode is placed lightly and evenly upon the skin, the secondary coil being removed from the primary, or the current otherwise reduced. The test begins with a weak current which is gradually increased until the patient feels the first light prickly or tingling sensation. Care must be taken that the lightest perceptible sensation is differentiated by the patient from the painful sensations of a stronger current. Note is taken of the strength of current required.

Electrical tests involve the same uncertain element as other tests for sensibility, the power of discrimination by the patient.

The examination has consequently limited diagnostic value, and may be taken only as corroborative evidence of variations in tactile or pain sense. These tests are made most satisfactorily in unilateral disease, which permits control experiments upon the healthy side. In cases of anæsthesia and analgesia, in which the ordinary tests fail to arouse a sensation, a very strong faradic current, administered by a wire brush electrode, may cause severe pain.

Loss of faradic sensibility has been reported in locomotor ataxia dissociated from other forms of sensory defect. The electro-cutaneous tests may be of service in detecting simulation. In such cases the minimal sensation is acknowledged by the patient with different strengths of current applied to the same areas in irregular succession. It is necessary that the patient sit with his back toward the battery, that he may not observe the manipulation. Cohn directs attention to the value of electro-sensory examinations in bilateral disease as a means of determining accurately by measurements the variations in sensibility from time to time.

Increased electro-cutaneous sensibility is found in tetany. Diseases of the vertebræ are discovered by the use of electricity. An electrode, preferably the negative pole of the galvanic current, passed slowly along the spine, causes pain at points of disease, and by this method single diseased vertebræ may be differentiated.

THE SPECIAL SENSES

Currents of electricity passed through the eye produce sensations of light, and through the ear, sensations of sound, these reactions appearing more readily with the cathodal than the anodal application of the galvanic current. Diseases of the second and eighth nerves may be attended by altered susceptibility to electricity, but these have, as yet, no diagnostic significance. The same is true of the senses of smell and taste.

ELECTRO-MUSCULAR SENSIBILITY

The muscles are said to be sensitive to electric currents, independently of their motor functions. Painful impressions have been produced in paralyzed muscles incapable of responding by contraction. Accompanying cutaneous anæsthesia is necessary for the purity of the test, a combination of conditions not easily obtained. The phenomenon has little or no diagnostic value.

Electric Resistance

The tissues of the body may be regarded as semi-fluids or solids of high degree of saturation, and thus as good conductors of electricity. The sole exception is the skin, which offers a disproportionately great resistance. The conditions influencing the conductivity of the skin are its density, permeability and moisture. In areas of thick epidermis and hairy investment, as the palms, soles and scalp, the resistance is much greater than in localities of thin epidermis or of numerous gland ducts or hair bulbs, as the skin of the neck or face, or of the mucous membranes. A moist or sweaty state of the skin promotes its conductivity. The continuous transmission of electricity lessens the resistance of the skin. There is thus a distinction between the "initial resistance" and the "constant resistance." In old age the initial resistance is great, but rapidly diminishes. In infancy the resistance is light. Pathologically the resistance of the skin is diminished in exophthalmic goitre and hysterical anæsthesia; and increased in the local areas of thickening in scleroderma, in myxœdema, elephantiasis and similar conditions. These variations are diagnostically unimportant, as not anticipating other more valuable symptoms. They are to be considered in the application of electricity for therapeutic and other purposes.

The Motor Points

The Motor Points

FIFTH NERVE

ACTION. Elevation and forward and lateral movements of the lower jaw.

MOTOR POINTS FOR THE MUSCLES

Masseter. In the sigmoid notch of the lower jaw, just below the zygoma.

Moderately strong current required.

Temporal. In a perpendicular line through the zygoma, a finger-breadth within the border of the hair.

Moderately strong current required.

SEVENTH NERVE

ACTION. Drawing of the face to the stimulated side and closing of the eyelid. The frontalis and corrugator supercilii often contract very weakly or not at all.

Motor Points. (1) In the angle between the mastoid process and the ramus of the lower jaw.

The electrode is to be pushed upward and forward against the lower half of the ear and the border of the jaw.

(2) In the depression just above the tragus.

This point is not constant and is better for excitation of the middle and lower branches.

POSTERIOR AURICULAR NERVE

ACTION. Retraction of the ear and scalp.

Motor Point. At the base of the mastoid process level with or slightly above the middle of the ear.

UPPER BRANCH OF THE SEVENTH NERVE

ACTION. Wrinkling of the forehead and eyebrow, and closing of the eyelids.

Motor Point. At the outer end of the superciliary ridge.

MOTOR POINTS FOR THE MUSCLES

Frontalis. At the outer and upper angle of the forehead near the border of the hair.

Painful! The test should be made quickly.

Corrugator supercilii. Over the eyebrow, a little inside the point for the upper facial branch.

Orbicularis oculi. Two points at the outer angle of the orbit.

MIDDLE BRANCH OF THE SEVENTH NERVE

ACTION. Expression of laughing, wrinkling of the nose and of the upper lip, or pouting of the lips.

Motor Point. At the junction with the zygoma of a perpendicular line dropped from the outer angle of the orbit.

MOTOR POINTS FOR THE MUSCLES

Nasal: Compressor, Pyramidalis and Dilator. At the inner angle of the eye near the root of the nose.

Levator labii superioris alaeque nasi. On the cheek just outside the nasal fold, level with the nares.

Zygomatici. On the cheek outside the point for the levator.

Orbicularis oris.

Upper Portion. A finger-breadth above the lip, inside the outer angle of the mouth.

Lower Portion. Near the lip and somewhat nearer the middle line than the point for the upper portion.

LOWER BRANCH OF THE SEVENTH NERVE

ACTION. Elevation of the chin, pouting of the under lip, and retraction of the angle of the mouth downward and outward.

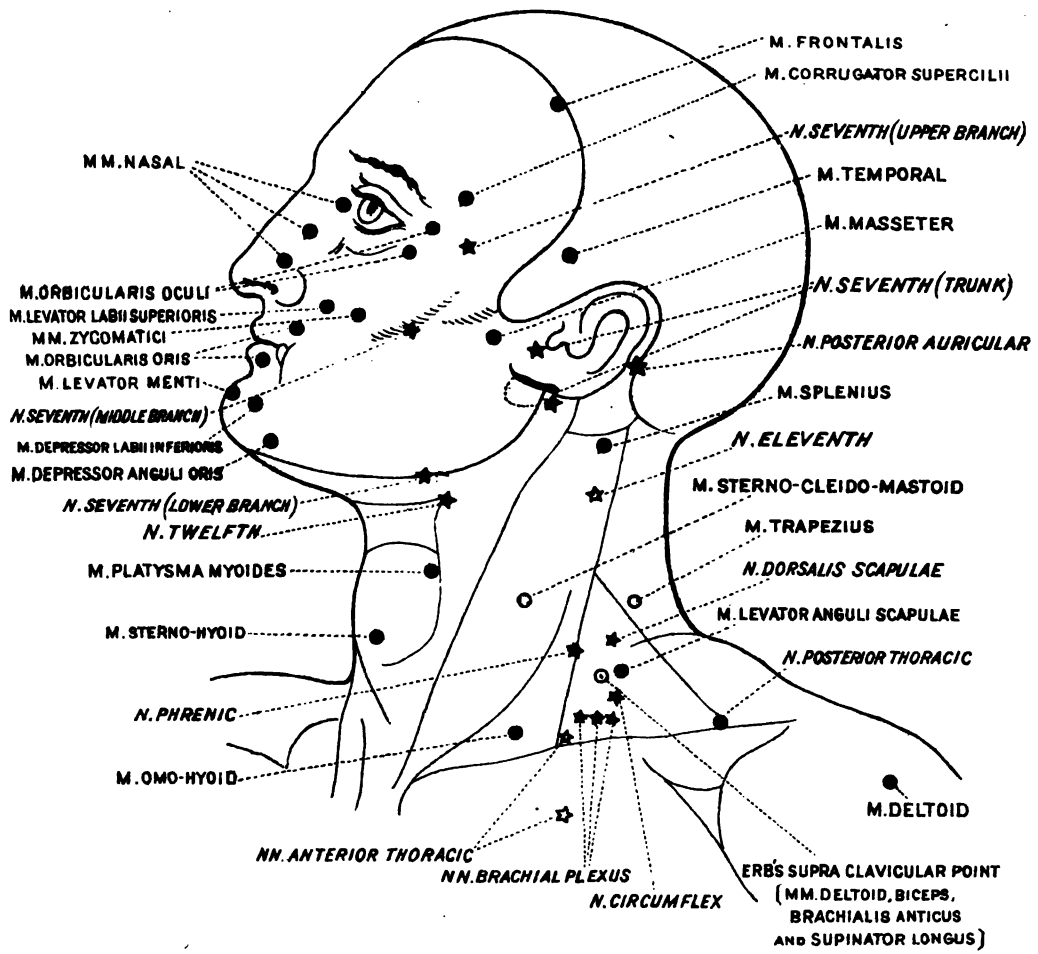
Motor Point. At the border of the lower jaw just back of the groove for the facial artery.

MOTOR POINTS FOR THE MUSCLES

Levator menti. Near the middle line of the chin just above the border of the lower jaw.

Depressor labii inferioris (*Quadratus menti*). A little outside and above the point for the levator.

PLATE I.



Mosher Electro-Diagnosis. Scheme for the Differential Testing of Nerves and Muscles.

Depressor anguli oris (*Triangularis menti*). Generally near the lower border of the jaw, a little outside the point for the depressor labii inferioris.

Platysma myoides. In the anterior cervical triangle level with the larynx.

ELEVENTH NERVE

ACTION. Extension of the head, and elevation and rotation of the chin toward the opposite side.

Motor Point. About two finger-breadths below the upper angle of the posterior cervical triangle, near the trapezius.

MOTOR POINTS FOR THE MUSCLES

Sterno-cleido-mastoid. At about the centre of the muscle.

Trapezius. At about the centre of the anterior edge of the muscle.

TWELFTH NERVE

ACTION. Movements of the tongue.

Motor Point. Close behind and above the hyoid bone.

MOTOR POINTS FOR THE MUSCLES

The intrinsic muscles of the tongue. Direct stimulation.

Omo-hyoid. Over the lower belly, between the insertions of the sterno-cleido-mastoid.

Sterno-hyoid. At the middle point of the belly of the muscle.

CERVICAL NERVES

External Branches of Posterior Division

ACTION. Drawing the head backward and downward.

MOTOR POINT FOR THE MUSCLE

Splenius capitis. Over the belly of the muscle close under the mastoid process.

PHRENIC NERVE

ACTION. Ballooning of the epigastrium and a noisy rush of air into the air passages.

Motor Point. Behind the edge of the sterno-cleido-mastoid, between the upper and middle thirds, sometimes farther below.

The electrode is to be pushed beneath the muscle.

BRACHIAL PLEXUS

ACTION. Depending on the point, usually the distribution of the median and circumflex :—flexion of the hand and fingers, elevation of the arm from the thorax, etc.

Motor Point. Mainly in the whole lower and inner third of the supraclavicular fossa; parts also may be easily stimulated outward therefrom.

DORSALIS SCAPULAE NERVE

(Third, Fourth and Fifth Cervical Nerves)

ACTION. Elevation of shoulder-blade with retraction toward spinal column.

Motor Point. In the middle line of the posterior cervical triangle, three finger-breadths above the clavicle.

MOTOR POINTS FOR THE MUSCLES

Rhomboids, major and minor. Direct stimulation, with intact trapezius, impossible.

Levator anguli scapulae. A finger-breadth below the point for the nerve and slightly behind it.

Not easily differentiated from the motor point for the nerve, inducing simultaneous contraction of the rhomboids.

LONG or POSTERIOR THORACIC NERVE

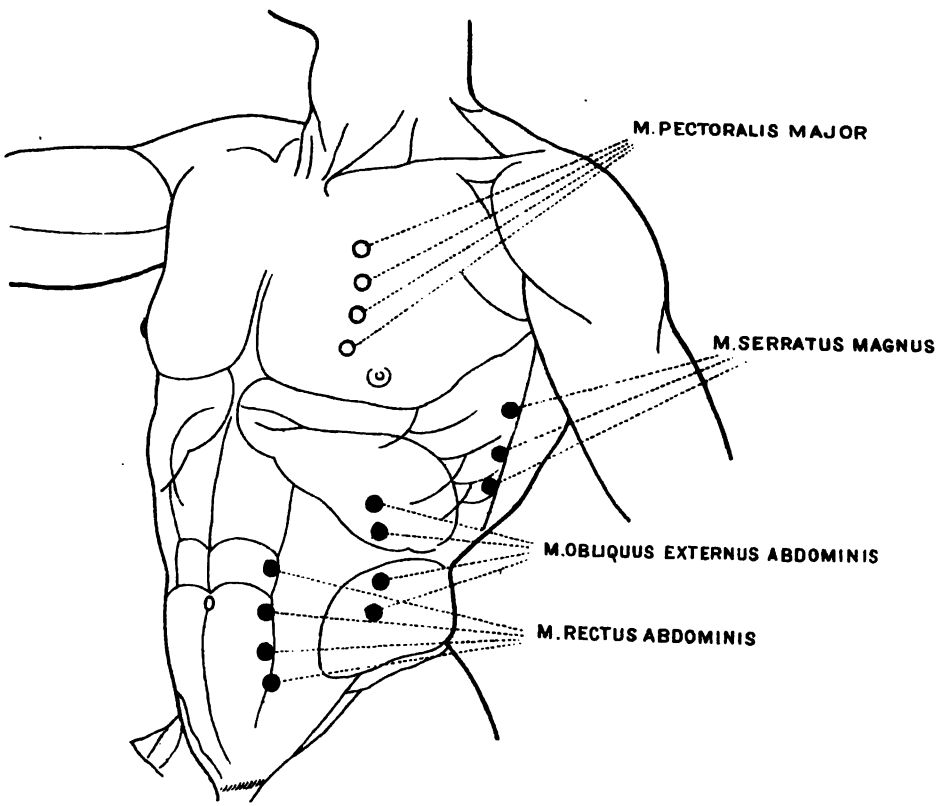
ACTION. Movement of the shoulder-blade outward and forward; or, visible contraction of the digitations of the serratus magnus.

Motor Point. Close above the clavicle in front of the edge of the trapezius.

MOTOR POINTS FOR THE MUSCLES

Serratus magnus. In the mid-axillary line, particularly at the level of the sixth rib.

PLATE II.



MOSHER *Electro-Diagnosis, Scheme for the Differential Testing of Nerves and Muscles.*

SUPRASCAPULAR NERVE

ACTION. Rotation of the humerus.

MOTOR POINTS FOR THE MUSCLES

Supraspinatus. Near the outermost angle of the supraspinous fossa, and only attainable when the trapezius is atrophied.

Infraspinatus. At about the middle of the infraspinous fossa. Not easily stimulated.

ANTERIOR THORACIC NERVES

ACTION. Adduction of the arm to the thorax.

Motor Points. (1) Close above and behind the clavicle, near the outer border of the sterno-cleido-mastoid.

(2) Just below the clavicle at the upper border of the pectoralis major.

The electrode is to be pushed deeply, with the patient's arm hanging, and a moderately strong current is to be used.

MOTOR POINTS FOR THE MUSCLES

Pectoralis major. Several, upon the anterior thoracic wall over the chondro-costal articulations.

LOWER SUBSCAPULAR NERVE

ACTION. Rotation of the humerus.

MOTOR POINTS FOR THE MUSCLES

Teres major. Occasionally, upon the muscle in the axilla.

LONG SUBSCAPULAR NERVE

ACTION. Adduction backward and downward of the arm.

MOTOR POINT FOR THE MUSCLE

Latissimus dorsi. At the anterior edge of the muscle, level with the angle of the scapula.

ERB'S SUPRACLAVICULAR POINT

ACTION. Backward elevation of the arm from the thorax, and strong flexion at the elbow in position of pronation.

(Muscles: Deltoid, biceps, brachialis anticus and supinator longus.)

Motor Point. Two finger-breadths above the clavicle, and one finger-breadth behind the border of the sterno-cleido-mastoid.

CIRCUMFLEX NERVE

ACTION. Elevation of the arm backward from the thorax.

Motor Point. In the middle line of the posterior cervical triangle, two finger-breadths above the clavicle.

MOTOR POINTS FOR THE MUSCLES

Deltoid. Direct stimulation of anterior and posterior bundles.
Teres minor. Occasionally upon the muscle in the axilla.

MUSCULO-CUTANEOUS NERVE

ACTION. Flexion of the forearm.

Motor Point. Two finger-breadths below the anterior axillary fold, at the inner border of the biceps.

MOTOR POINTS FOR THE MUSCLES

Biceps. Over the belly of the muscle.

Coraco-brachialis. (1) At the inner border of the biceps, just below the centre.

(2) At the outer border of the biceps, three finger-breadths above the elbow.

Push the electrode, which should be small, under the biceps muscle.

Brachialis anticus. Behind the inner side of the biceps tendon in the lower third of the arm.

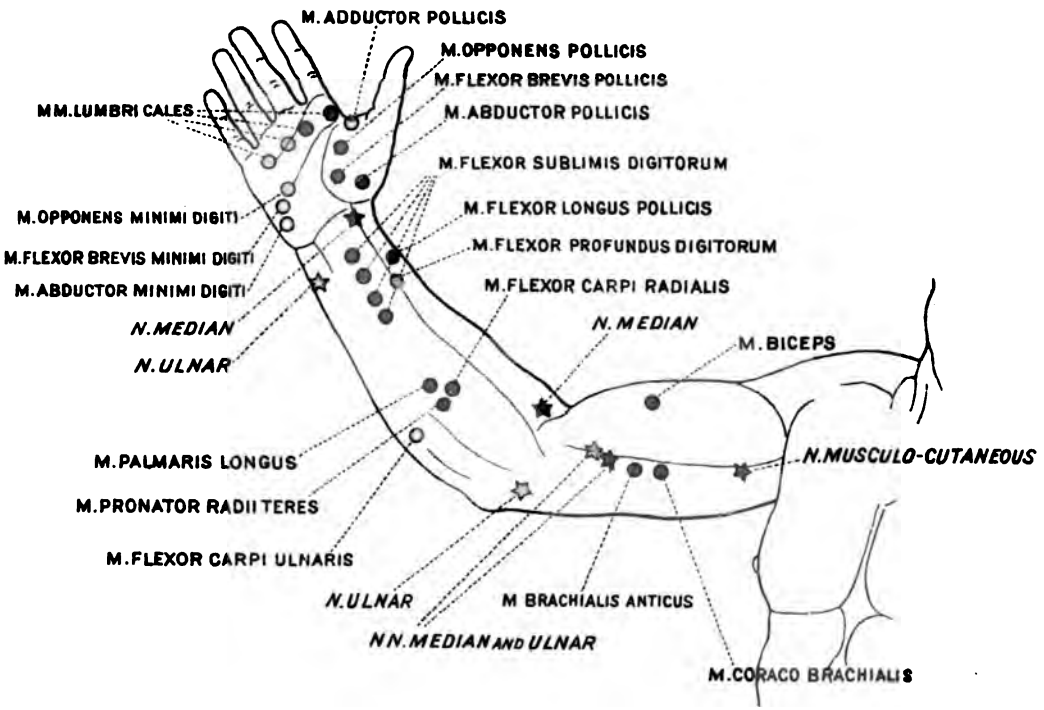
Not easily stimulated when the biceps is intact.

MEDIAN and ULNAR NERVES

The ulnar and median nerves are easily stimulated simultaneously throughout the groove at the inner side of the biceps muscle (*Sulcus bicipitalis internus.*)

The best position of the arm for the stimulation of these nerves and their muscles is one of very slight flexion, with greatest possible relaxation of the muscles. Only a weak current is needed.

PLATE III



MOSHER *Electro-Diagnosis Scheme for the Differential Testing of Nerves and Muscles*

In the hand the thenar and hypothenar muscles are most easily stimulated, and the lumbricales are often difficult to reach.

The reactions of the forearm and hand differ greatly in different people.

MEDIAN NERVE

ACTION. Pronation of the forearm, flexion and abduction of the hand, opposition and flexion of the thumb, flexion of the second and third phalanges of the fingers.

Motor Points. (1) In the middle of the elbow joint, usually directly outside of the biceps tendon.

(2) In the middle of the wrist joint, between the tendons of the flexor carpi radialis and palmaris longus, or at the ulnar border of the latter.

MOTOR POINTS FOR THE MUSCLES

Pronator radii teres. Three finger-breadths below the elbow joint, at the outer margin of the bundle of flexor muscles.

Palmaris longus. A finger-breadth below the point for the pronator radii teres, and slightly nearer the middle line.

Often difficult to differentiate from the flexor carpi radialis.

Flexor carpi radialis. Directly below the point for the pronator radii teres, and a finger-breadth toward the radial side of the forearm.

Flexor sublimis digitorum. Several, in the middle and lower thirds of the forearm, in a line from the internal condyle to the middle of the palm, and also toward the radial border of the forearm.

Flexor longus pollicis. Four finger-breadths above the wrist on the radial border.

Thenar Muscles: Opponens pollicis, Flexor brevis pollicis, Abductor pollicis. The points lie in a slightly curved line on the ball of the thumb.

Third and Fourth Lumbricales. In common with the points for the interossei supplied by the ulnar nerve.

ULNAR NERVE

ACTION. Ulnar flexion of the hand and the first phalanges of the fingers; adduction of the thumb.

Motor Points. (1) Between the inner condyle and the olecranon, about one finger-breadth above the condyle.

(2) On the ulnar side of the forearm a little above the wrist.

MOTOR POINTS FOR THE MUSCLES

Flexor carpi ulnaris. On the border of the forearm between the flexor and extensor surfaces, one hand-breadth below the internal condyle.

Flexor profundus digitorum. In the middle of the forearm, level with the principal point for the flexor sublimis digitorum, toward the radial border.

Not easily differentiated from the flexor sublimis digitorum.

Adductor pollicis. On the dorsal surface in the angle between the thumb and index finger.

Usually in combination with other small muscles of the thumb.

Hypothenar Muscles: Abductor minimi digiti, Flexor brevis digiti minimi, Opponens minimi digiti. In a slightly curved line on the ball of the little finger.

Lumbricales and Interossei. In the interosseous spaces on the back of the hand, somewhat nearer the wrist than the bases of the fingers.

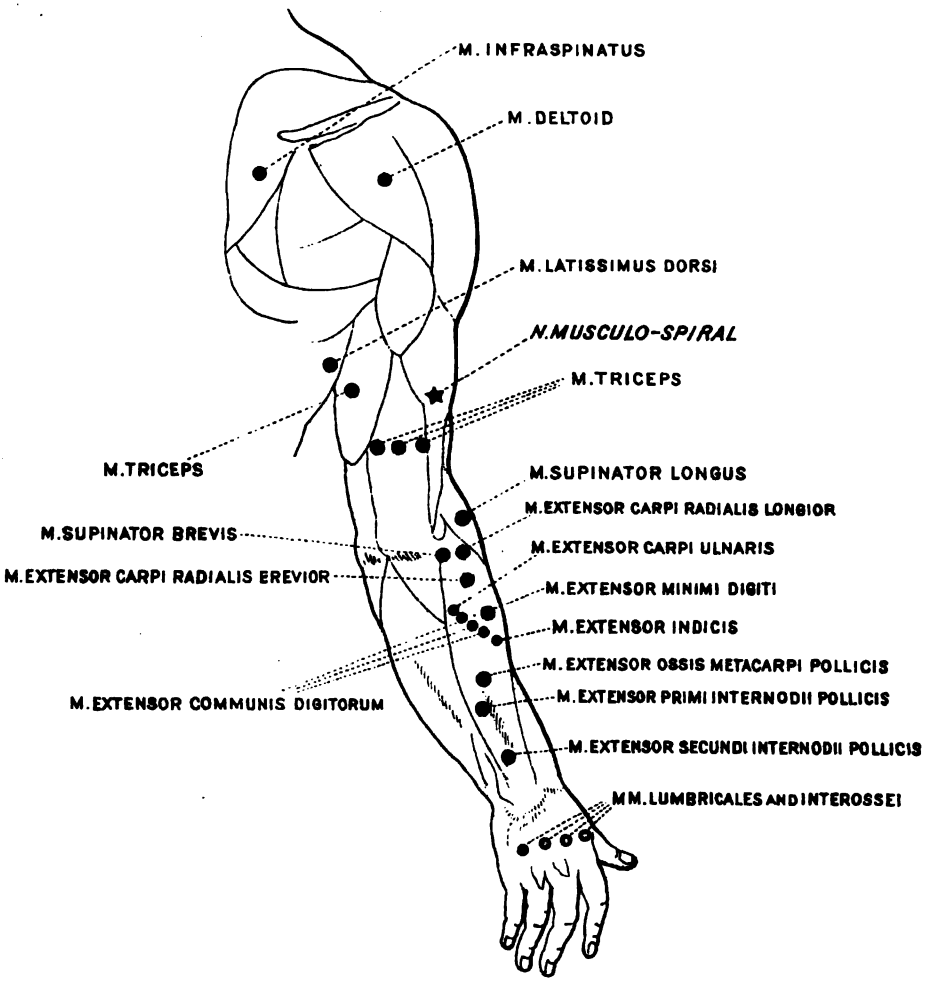
MUSCULO-SPIRAL NERVE

ACTION. Extension of forearm, hand and fingers, with supination.

Motor Point. Slightly outside the point between the external condyle and the insertion of the deltoid.

The electrode is to be pushed firmly and deeply between the biceps and triceps muscles, against the musculo-spiral groove. The application is sometimes painful and difficult.

PLATE IV.



MOSHER *Electro-Diagnosis, Scheme for the Differential Testing of Nerves and Muscles.*

Albany Lithog.

MOTOR POINTS FOR THE MUSCLES

Triceps. Three points for the three heads usually in a horizontal line a hand-breadth above the olecranon. The long head may be also stimulated two finger-breadths below the posterior axillary fold.

Supinator longus. Close above and in front of the external condyle.

Extensor carpi ulnaris. Close to the posterior border of the ulna on its radial side, a hand-breadth below the olecranon.

Extensor indicis. Slightly above the middle of the forearm on a line from the external condyle to the base of the index finger.

Extensor communis digitorum. A series on an oblique line from the point for the extensor carpi ulnaris to the point for the extensor indicis, particularly at the middle point of this line.

Extensor minimi digiti. One or two finger-breadths inside and slightly above the point for the extensor indicis.

Extensor carpi radialis longior. Three finger-breadths below the external condyle, in the groove behind the supinator longus.

Extensor carpi radialis brevior. Two or three finger-breadths below the point for the long radial extensor.

Not easily differentiated from the Extensor communis digitorum.

Supinator brevis. Below and within the external condyle.

A difficult muscle to stimulate, unless in atrophy of the overlying muscles. Cohn notes that in many persons there is a response to only one faradic pole, whereas the other at the same point, elicits a response of some other muscle, as one of the extensors of the hand.

Extensor ossis metacarpi pollicis. Between the points for the extensor indicis and the extensor primi internodii pollicis.

Extensor primi internodii pollicis (*Extensor pollicis brevis*). In the centre of the extensor surface of the forearm, three finger-breadths above the wrist.

Extensor secundi internodii pollicis (*Extensor pollicis longus*). In the centre of the extensor surface of the forearm, one finger-breadth above the wrist.

UPPER INTERCOSTAL NERVES

ACTION. Movements of the ribs.

Motor Points. On the upper borders of the intercostal spaces.

Use a small electrode. Electrical stimulation unimportant.

LOWER INTERCOSTAL NERVES

ACTION. Retraction of the abdomen.

MOTOR POINTS FOR THE MUSCLES

Obliquus externus abdominis. Several, over the belly of the muscle, between the costal margin and the crest of the ilium.

Rectus abdominis. Several, along the outer border of the muscle, most easily below the umbilicus.

OBTURATOR NERVE

ACTION. Adduction of thigh.

Motor Point. At the outer end of the horizontal ramus of the pubis.

MOTOR POINTS FOR THE MUSCLES

Adductors (Longus, brevis, and magnus). Several, on the inner surface of the thigh, at the junction of the upper and middle thirds.

ANTERIOR CRURAL NERVE

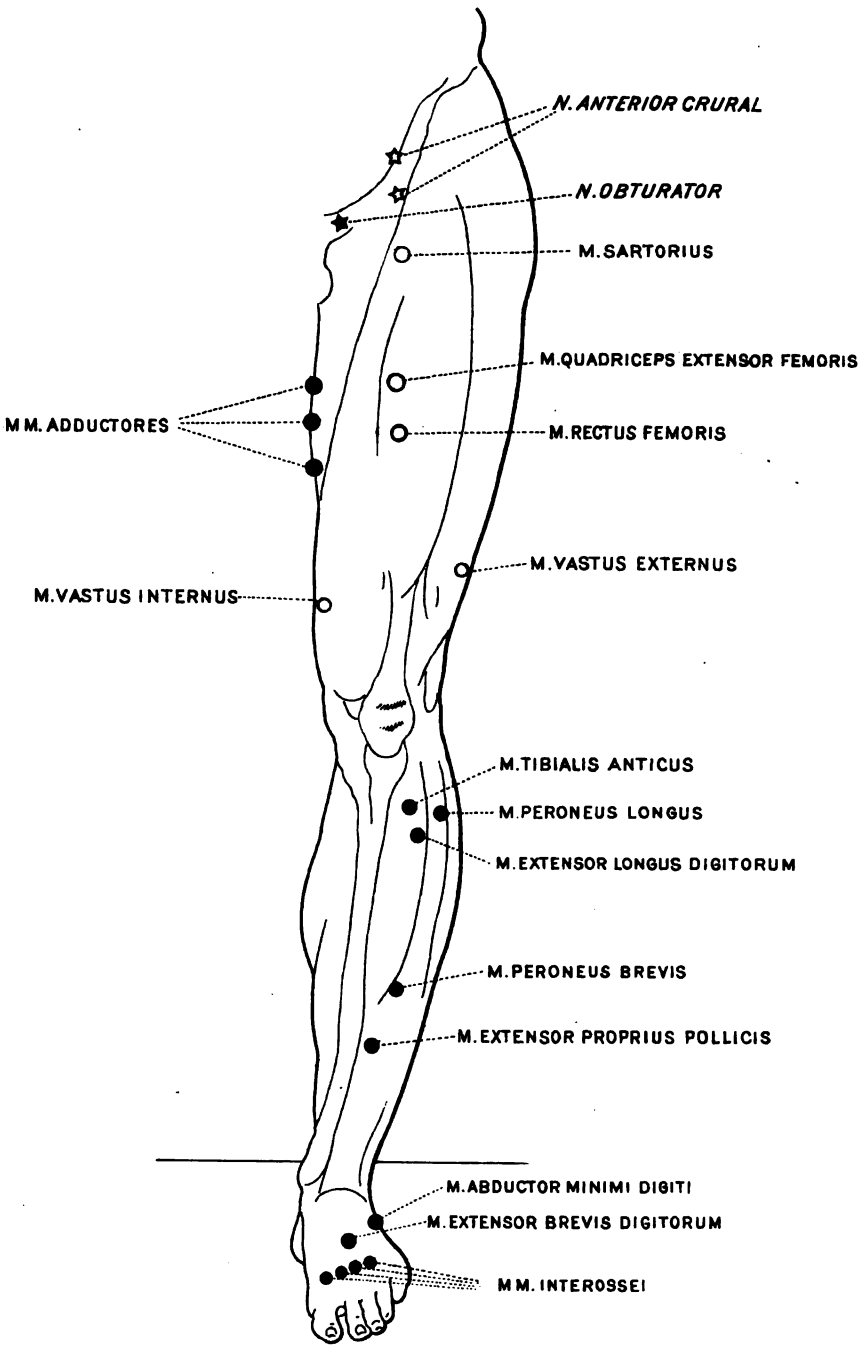
ACTION. Extension of the leg.

Motor Points. (1) Above and behind the middle of Poupart's ligament.

Deep pressure with the electrode.

(2) In Scarpa's triangle just outside of the femoral artery.

PLATE V.



MOSHER *Electro-Diagnosis. Scheme for the Differential Testing of Nerves and Muscles*

MOTOR POINTS FOR THE MUSCLES

Sartorius. Over the belly of the muscle a hand-breadth below Poupart's ligament.

Quadriceps extensor femoris. At the junction of the upper and middle thirds of the thigh at the inner border of the rectus muscle.

Vastus internus. A hand-breadth above the patella on the inner side of the muscular bundle.

Easily stimulated.

Vastus externus. On the outer side of the muscular bundle, about two hand-breadths above the patella.

Rectus femoris. At the middle point of the anterior surface of the thigh, just below the point for the quadriceps extensor.

SUPERIOR GLUTEAL NERVE

ACTION. Extension of hip and abduction of thigh.

MOTOR POINTS FOR THE MUSCLES

Gluteus medius. Between the trochanter major and the crest of the ilium.

This test is much more satisfactorily made when the patient is made to stand on the limb not under examination, and support himself by his hands.

Tensor vaginae femoris. High upon the outer border of the thigh, just in front of the trochanter major.

SMALL SCIATIC NERVE

ACTION. Extension, abduction and rotation of thigh outward; elevation and adduction of buttock.

MOTOR POINTS FOR THE MUSCLES

Gluteus maximus. Several points over the belly of the muscle.

GREAT SCIATIC NERVE

ACTION. Flexion of the leg and plantar flexion of the foot.

Motor Point. Midway between the trochanter major and the tuberosity of the ischium in the gluteo-femoral crease, or just below it.

MOTOR POINTS FOR THE MUSCLES

Semi-tendinosus and Semi-membranosus. At the middle of the inner border of the thigh.

At a common point just above the former the long head of the biceps may be also simultaneously stimulated.

Biceps. At the outer side of the thigh below the level of the point for the semi-membranosus and semi-tendinosus.

INTERNAL POPLITEAL (TIBIAL) NERVE

ACTION. Flexion and wrinkling of the skin of the sole, and plantar flexion of the toes.

The wrinkling of the skin of the sole is particularly characteristic.

Motor Points. (1) Just above the middle of the popliteal space.

(2) Between the internal malleolus and the tendon of Achilles.

MOTOR POINTS FOR THE MUSCLES

Gastrocnemius. Over each head of the muscle, a hand-breadth below the knee.

Soleus. Over the body of the muscle not covered by the gastrocnemius; the outer head also a hand-breadth higher than the inner.

The preliminary test of the gastrocnemius reveals its outlines and facilitates the test of the soleus.

Flexor longus digitorum. A hand-breadth above the internal malleolus.

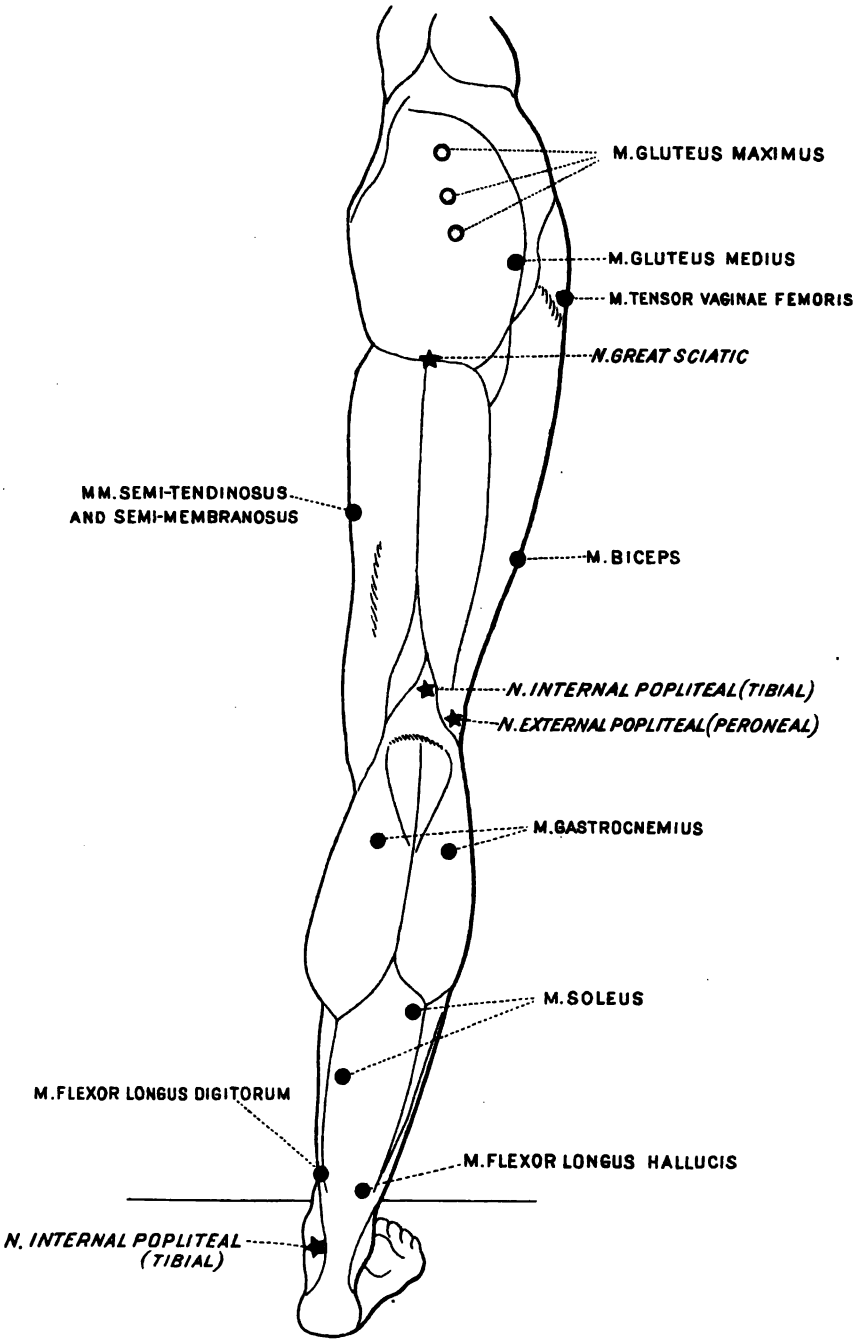
Flexor longus hallucis. Two or three finger-breadths above the external malleolus, close against the fibula.

Deep pressure with the electrode.

Interossei. Analogous with the points on the hand.

Abductor minimi digiti. On the outer border of the foot between the middle and posterior thirds.

PLATE VI.



MOSHER *Electro-Diagnosis. Scheme for the Differential Testing of Nerves and Muscles.*

EXTERNAL POPLITEAL (PERONEAL) NERVE

ACTION. Dorsal flexion of the foot and extension of the toes.

Motor Point. At the outer angle of the popliteal space, close to the inner border of the tendon of the biceps.

The best position for the examination of the leg nerves and muscles is attained when the patient is recumbent, with the knee slightly flexed. Pressure is to be applied directly.

MOTOR POINTS FOR THE MUSCLES

Tibialis anticus. Two finger-breadths below the external tuberosity of the tibia, close to the crest.

In children, at the junction of the upper and middle thirds of the leg.

Peroneus longus. Two or three finger-breadths below the head of the fibula.

Peroneus brevis. Halfway between the head of the fibula and the external malleolus.

A moderately severe current required.

Extensor longus digitorum. Three finger-breadths below the external tuberosity of the tibia.

In children, at the junction of the upper and middle thirds, directly outside the point for the tibialis anticus.

Extensor proprius pollicis. Close to the outer edge of the crest of the tibia, a variable distance (two to four finger-breadths) above the ankle.

Extensor brevis digitorum. Between the external malleolus and the base of the toes.

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